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Stochastic Modeling of Rainfall Data in the Agro Claimatic Area Kanchipuram

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ABSTRACT:
Monsoon is one of the most unpredictive phenomena of Nature. Throughout the world, scientists are at it over several decades; still no exact solution with higher probability level is reached by any of them. By the advancement of the computer now scientists are able to come to a closer level than before as seen from the current reviews of literature. This has given a scope for the young researcher to select this area and attempt the problem. Markov transition probability is obtained to know the probability of transition from each possible state to all the other remaining states and the stationary distributions.

Methodology

The Markov transition probability analysis was carried out by using the transition probability P_{ij} = P {x = j / x =i} which gives the transition probability of the Markov chain, from the state i to the state j. The stochastic process $\{X_n, n= 0,1,2,....... \}$ is called a Markov chain for $j, k, j_1, ..., j_{n-1} \in N$, If $P \{X_n = k / X_{n-1} = j, X_{n-2} = j_1, \ldots\ldots, X_0 = j_{n-1}\} = Pr \{X_n = k / X_{n-1} = j\} = p_{jk}$, p_{jk} is called the Markov transition probability. If X_n has the outcome j (ie, X_n =j) the process is said to be in state j at the n^{th} trial. The transition probability p_{jk} refers to the states (j, k) at two successive trials and in this case the transition is one step and p_{jk} is called one step transition probability.

The transition probabilities p_{ij} satisfy $p_{jk} \geq 0$ and $\sum_k p_{jk} = 1$ for all j.

These probabilities may be written in the matrix form as

$$P = \begin{pmatrix} p_{11} & p_{12} & p_{13} & \cdots \\ p_{21} & p_{22} & p_{23} & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \end{pmatrix}$$

This is the transition probability matrix or matrix of transition probabilities of a Markov chain.

In the Harmonic Analysis it was seen that for almost all the fourteen stations the results were very close to the observed values at the seventh or eighth or ninth harmonic. Hence the researcher tends to go in for the Markov transition probabilities. The dimension of the transition probability matrix differs from place to place due to the nature of the rainfall in each station. For uniformity the transition intervals were taken as 1 - 50cm (E_1), 51-100 cm (E_2) 101 - 150 cm (E_3), 151 - 200 cm (E_4) , 201 - 250 cm (E_5), 251-300 cm (E_6), 301 - 350 cm (E_7) and 351 - 400 (E_8). Only in high rainfall areas it has come up to 301 - 350 cm. In the above representation if the dimension of a matrix is four it implies that in the transition probability matrix for that region, the maximum rainfall is between 151 - 200 cm. In case there is a stray rainfall above 200 cm in one or two occasions alone it is represented as above 150 cms (or greater than 150 cms as the last class) in the classification. In this way the transition probability matrices were constructed for all stations except Kollimalai wherein the rainfall is very high so that the dimension of the matrix goes beyond limit. The maximum rainfall reached is 5862.42 cms.

Computational Analysis:

The following notations are used for all the stations just for brevity.

P_1 = Markov transition probability matrix from May to June.
P_2 = Markov transition probability matrix from June to July.
P_3 = Markov transition probability matrix from July to August.
P_4 = Markov transition probability matrix from September to October.
P_5 = Markov transition probability matrix from October to November.
P_6 = Markov transition probability matrix from November to December.

The Markov transition probability matrices for the selected places in the seven agro-climatic zones are given below. In Table 1.1 we have presented the results for Kancheepuram .

Table 1.1 Kancheepuram

$$P_1 = \begin{pmatrix} 0.4000 & 0.4500 & 0.0500 & 0.1000 \\ 0.5714 & 0.2857 & 0.0000 & 0.1429 \\ 1.0000 & 0.0000 & 0.0000 & 0.0000 \\ 0.5000 & 0.5000 & 0.0000 & 0.0000 \end{pmatrix}$$

$$P_2 = \begin{pmatrix} 0.4400 & 0.2800 & 0.0800 & 0.2000 \\ 0.1875 & 0.3750 & 0.1250 & 0.3125 \\ 0.0000 & 0.3333 & 0.3333 & 0.3334 \\ 0.2000 & 0.6000 & 0.2000 & 0.0000 \end{pmatrix}$$

$$P_3 = \begin{pmatrix} 0.1333 & 0.2667 & 0.2000 & 0.2000 & 0.2000 \\ 0.2105 & 0.1579 & 0.2105 & 0.1579 & 0.2632 \\ 0.2000 & 0.2000 & 0.4000 & 0.2000 & 0.0000 \\ 0.0000 & 0.1111 & 0.4444 & 0.2222 & 0.2222 \\ 0.0000 & 1.0000 & 0.0000 & 0.0000 & 0.0000 \end{pmatrix}$$

$$P_4 = \begin{pmatrix} 0.0000 & 0.3333 & 0.2222 & 0.1111 & 0.1111 & 0.2222 \\ 0.0769 & 0.0769 & 0.3077 & 0.2308 & 0.3077 & 0.0000 \\ 0.0000 & 0.0000 & 0.2727 & 0.2727 & 0.0909 & 0.3636 \\ 0.0000 & 0.2000 & 0.4000 & 0.2000 & 0.0000 & 0.2000 \\ 0.0000 & 0.0000 & 0.0000 & 0.5000 & 0.2500 & 0.2500 \\ 0.0000 & 0.2500 & 0.5000 & 0.0000 & 0.1250 & 0.1250 \end{pmatrix}$$

$$P_5 = \begin{pmatrix} 0.0000 & 1.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ 0.0000 & 0.1429 & 0.1429 & 0.2857 & 0.1429 & 0.2857 \\ 0.1429 & 0.0714 & 0.2857 & 0.2143 & 0.1429 & 0.1429 \\ 0.0000 & 0.0000 & 0.2000 & 0.2000 & 0.1000 & 0.5000 \\ 0.1667 & 0.0000 & 0.5000 & 0.0000 & 0.3333 & 0.0000 \\ 0.0000 & 0.2222 & 0.3333 & 0.1111 & 0.1111 & 0.2222 \end{pmatrix}$$

$$P_6 = \begin{pmatrix} 0.6667 & 0.0000 & 0.0000 & 0.0000 & 0.3333 \\ 0.6667 & 0.3333 & 0.0000 & 0.0000 & 0.0000 \\ 0.4545 & 0.1818 & 0.1818 & 0.0909 & 0.0909 \\ 0.6667 & 0.0000 & 0.1111 & 0.1111 & 0.1111 \\ 0.3333 & 0.3333 & 0.1905 & 0.0476 & 0.0952 \end{pmatrix}$$

Now in order to know whether the power of the Markov transition probability matrix is related to the harmonic number, which gives the least variation between the observed and the expected values, the powers of the transition probability matrices were computed for each one of the transition matrices for all the selected regions.

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